SECTION 9: DECKS AND DECK SYSTEMS

TABLE OF CONTENTS

9.1 SCOPE

This Section contains guidelines to supplement provisions of Section 9 of the AASHTO LRFD Bridge Design Specifications for the design of bridge decks and deck systems of reinforced concrete, prestressed concrete, metal, or various combinations thereof.

All design engineers are advised to review the example problems in Appendix – A of these guidelines for proper and correct application of various provisions of the AASHTO LRFD Specifications and these guidelines for design of bridge structural components.

9.4 GENERAL DESIGN REQUIREMENTS

Minimum concrete strength of bridge decks shall be, f'_c = 4.5 ksi at 28 days.
Refer to Section 5, Article 5.4 Material Properties, of these guidelines for other requirements.

To provide protection against corrosion the minimum clear cover for reinforcing steel in new deck slabs shall be 2½ inch for top reinforcement and 1 inch for the bottom reinforcement.

Only #5 or #6 bar sizes shall be used as primary reinforcement in the transverse direction and shall be spaced at 1/2-inch increments. Minimum reinforcing spacing shall be 5 inches. Normally maximum transverse reinforcement spacing should not exceed 9 inches.

Bar sizes up to #11 may be used as primary reinforcement in the longitudinal direction in slab bridges. This also applies to continuity reinforcement over piers.

All new bridge construction located above an elevation of 4000 feet, or for areas where de-icing chemicals are used, deck slabs, barriers, anchor slabs and approach slabs reinforcing as well as portions of reinforcement projecting into the deck slabs shall be epoxy coated.

Deck protection systems shall be discussed in the Bridge Selection Report. Recommended options, other than epoxy coated reinforcing, shall be coordinated with ADOT Materials Group and shall be approved by ADOT Bridge Group.

For existing bridges, latex modified concrete overlay, silica-fume concrete overlay or a membrane system with a bonded wearing surface are alternate protection systems that may be considered. Implementation of either one of these alternatives requires coordination with ADOT Materials and Bridge Groups.

A 3/4" V-drip groove shall be located on the underside of the deck overhang for all steel girder bridges. It shall also be used for concrete bridges when a steel rail barrier system is used.

9.5 LIMIT STATES

9.5.2 Service Limit States

Deck design is controlled by Service Limit State I. The behavior of bridge decks shall be considered elastic. Decks shall be designed by the working stress method and as stated in this section.

Allowable tensile stress in transverse reinforcing steel, f_s, shall be limited to 24 ksi.

9.6 ANALYSIS

9.6.1 Methods of Analysis

The most typical deck system used in Arizona is a cast-in-place deck slab spanning transversely over a series of girders. This type of deck shall be designed using an approximate elastic method and the criteria stated in this section.

Refined methods of analysis, such as the Finite Element Method, shall only be used for unconventional, complex structures and with prior approval from ADOT Bridge Group.

Dead load analysis shall be based on a strip method using the following simplified moment equation for both positive and negative moments:

$wS^2/10$, for deck slabs that are continuous over three spans or more
$wS^2/8$, for all other cases

where:

S = the effective span length specified in AASHTO LRFD Article 9.7.2.3
w = the uniformly distributed dead load of the slab system

The unfactored live load moments shall be obtained from AASHTO LRFD Section 4, Appendix A, Table A4-1. Negative moment values should be based on a distance of 0.0 inch from the centerline of girder to the design section.

9.7 CONCRETE DECK SLABS

9.7.1 General

9.7.1.1 Minimum Depth and Cover

The thickness of new deck slabs shall be designed in $^1/_2$" increments with the minimum thickness as follows:

S (ft)	≤ 7	> 7 and ≤ 8.5	> 8.5 and ≤ 10	> 10 and ≤ 11.5	> 11.5 and ≤ 13
t (in)	8.0	8.5	9.0	9.5	10.0

where:

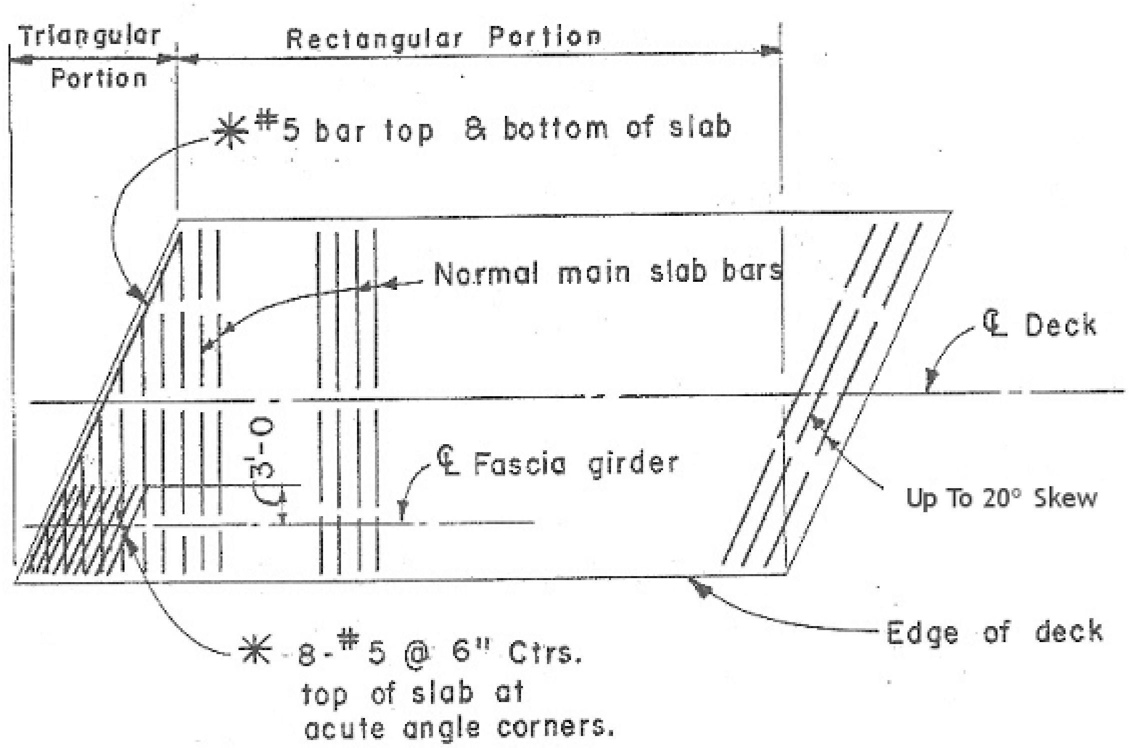
S = the effective span length specified in AASHTO LRFD Article 9.7.2.3
t = Minimum thickness of deck slab

Note that the slab thickness, t, includes ½ inch wearing surface, which must be excluded for strength service analysis.

9.7.1.3 Skewed Decks

For a skew angle less than or equal to 20 degrees, the primary reinforcement shall be placed parallel to the skew. For skews greater than 20 degrees the reinforcing shall be placed perpendicular to the main supporting members. The effects of the skew shall be accounted for by providing additional short bars at the deck corners as shown in the figure below. Truss bars shall not be used.

Skewed Girder Bridges



∗ Use for Skews of 20° and more at each skewed corner.

9.7.3 Traditional Design

9.7.3.2 Distribution Reinforcement

Distribution reinforcement shall be calculated in accordance with AASHTO LRFD Article 9.7.3.2. The required reinforcement shall be placed in the secondary direction throughout the effective span length between girders in the bottom of the slab.

9.7.4 Stay-in-Place Formwork

9.7.4.1 General

Use of stay-in-place (SIP) formwork should be investigated for each bridge site during preliminary design and a discussion of this issue should be included in the Bridge Selection Report. Use of a SIP formwork system should be considered for the following situations:

- When bridges span high traffic volume roadways, deep canyons, perennial streams or canals.
- Where removal of conventional formwork would be difficult or hazardous.

When a SIP formwork system is selected, the contract documents shall include conceptual design and connection details for the SIP system. The contractor shall submit all SIP formwork design calculations and connection details to the design engineer for approval. Shop drawings for the girders including the location of inserts and the SIP formwork, shall be submitted concurrently for review and approval.

9.7.4.2 Steel Formwork

Steel formwork is the preferred stay-in-place formwork for bridge deck construction. The design engineer shall assume an additional 15 psf of dead load due to the weight of the forms and the concrete in the flutes. SIP formwork flutes shall only be filled with structural concrete, use of foam or polystyrene is not allowed.

Steel formwork shall not be considered to be composite with the concrete deck slab. The construction plans should state the assumed additional weight that the deck, girder and substructure have been designed for due to this method of construction.

If the SIP formwork is the only method of construction allowed the additional concrete in the steel flutes shall be included in the estimate of deck concrete quantities. If it is an option the additional quantity of concrete is not part of the deck concrete quantities and needs to be clearly stated in the plans.

The steel formwork shall be galvanized for corrosion protection.

9.7.4.3 Concrete Formwork

Precast stay-in-place concrete panels used with a cast-in-place concrete topping to create a final composite deck are another form of formwork for deck construction. The panels are designed to span transversely between the girders and are usually prestressed. Precast concrete deck panels are not recommended for SIP formwork due to the complexity of design and construction parameters such as:

Transfer and development lengths
Correct location of strands or reinforcing
Difficulty in providing for girder camber and proper seating of the panels
Longitudinal discontinuity resulting in possible reflective cracking at the ends of each panel
Difficulty in ensuring composite action with the cast-in-place concrete
Combined shrinkage and creep effects

Precast prestressed concrete deck panels may be considered for major or unusual girder bridges. A full discussion justifying the use of precast concrete deck panels, including all design and construction parameters, must be included in the Bridge Selection Report before final approval can be considered.

DECK OVERHANG DESIGN

The deck overhang shall be designed in accordance with AASHTO LRFD Section 13, Appendix A, Article A13.4. For Design Case 1, the deck shall be designed to resist both the axial force and the bending moments due to the dead load and the horizontal railings impact load. The vertical wheel load shall not be applied simultaneously with these loads. The net tensile strain in the extreme tension steel in the overhang reinforcing for Design Case 1, Extreme Event Load Combination II limit state, shall not exceed 0.025.

For Design Case 3 both the strength and service limit states shall be investigated. In the Service Limit State the design live load distribution shall be determined using Table 4.6.2.1.3-1.

When traffic barriers are located at the edge of the deck, the slab thickness of the overhang shall be at least 1 inch greater than the interior slab thickness. Deck reinforcement resisting overhang loadings shall be fully developed at the section under consideration. Reinforcing steel larger than #5 bars may require hooks at the edge of deck for development length.

Concrete barriers on continuous superstructures should have a $^{1}/_{2}$ inch open joint filled with bituminous joint filler located over piers. The joint should extend to within 8 inches of the deck surface with reinforcing below this level made continuous.

The values in the following table shall be used for the design of the deck overhang in conjunction with ADOT Bridge Group Standard Drawings (SD) for concrete barriers. Refer to the AASHTO LRFD Section 13, Appendix A, Article A13.3 for definition of the symbols contained in the table.

Barrier Type	M_b	R_w	M_c	M_w	Top rail M_p	Bot. rail M_p	Post M_p
SD 1.01 32" F shape	0	58.83 kips	6.17 [a]	28.66	--	--	--
SD 1.02 42" F shape	0	129.6 kips	15.16 [b]	56.42	--	--	--
SD 1.04 Parapet Rail [c]	0	--	12.04	30.15	12.65	12.65 [d]	14.99
SD 1.06 Two Tube Rail	--	--	--	--	41.78	29.21	93.75

a. M_c = 14.91 at open joints
b. M_c = 24.24 at open joints
c. assumes 11-inch curb height at parapet
d. when fence is omitted

RAILINGS

New railing shall be designed in accordance with the latest AASHTO LRFD Specifications, Section 13 and these guidelines.